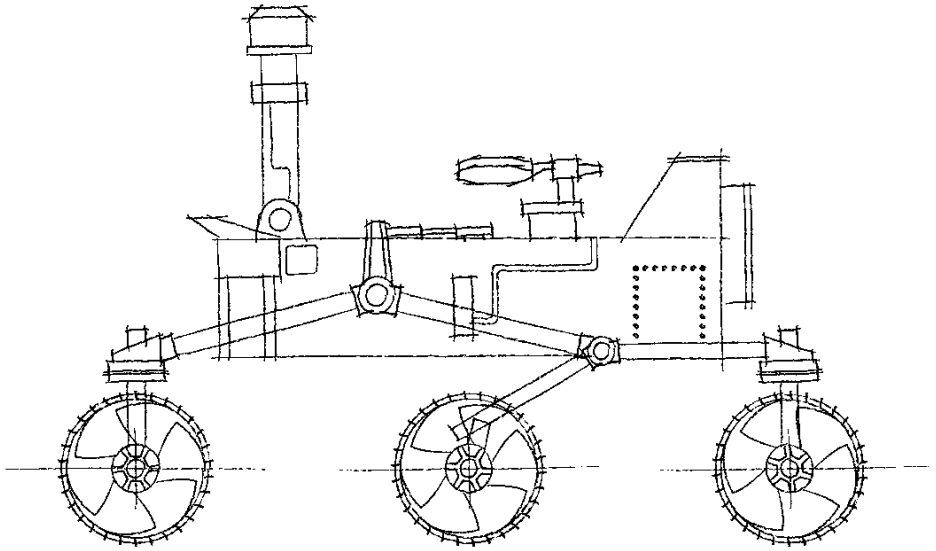
Jet Propulsion Laboratory
California Institute of Technology

Preliminary Traverse Distance Estimates for Sites

Landing Site Workshop #2

8/4/2015 – 8/6/2015

Matt Heverly
Hiro Ono



Mars 2020 Project

Team

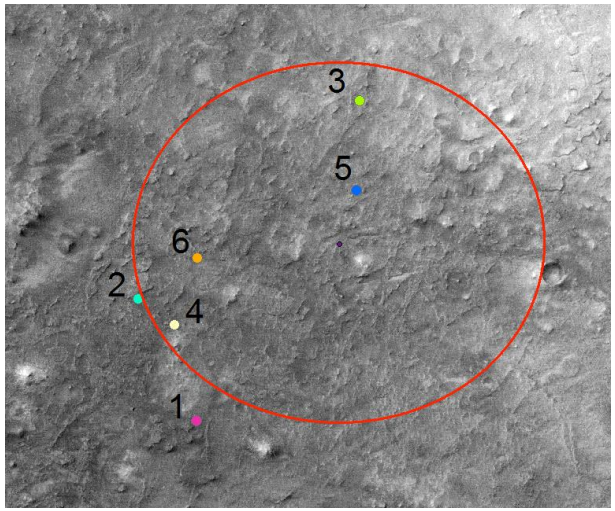
- Hiro Ono
- Andreas Huertas
- Eduardo Almeida
- Brandon Rothrock
- Adnan Ansar

Objective

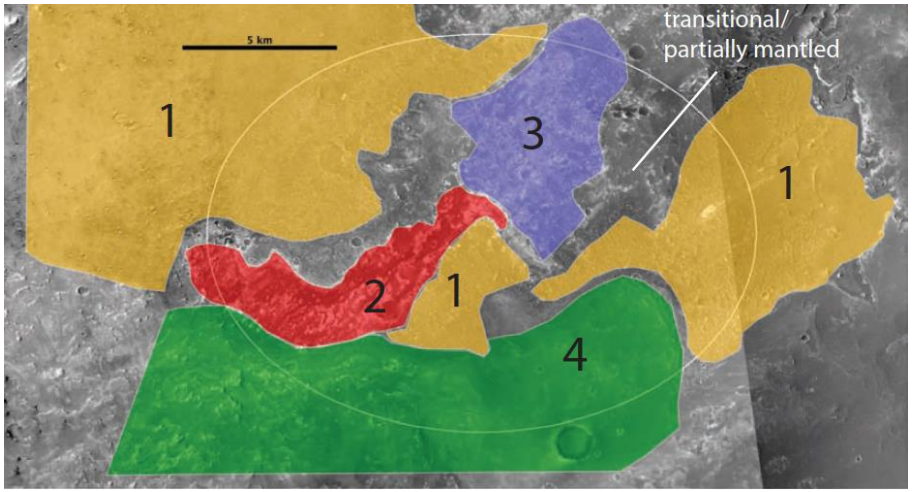
- Relative comparison of traverse distance required at each site to achieve a representative mission scenario

Regions Of Interest (ROIs)

- Team at JPL interpreted the submitted ROIs to define a representative scenario for exploring each site.
  - Each site requires exploration of two ROIs for this exercise
  - Some ROIs are now defined as the contact between geological units
- ROI definition and “must visit” set have a big impact on traverse requirements at the site. We will work with science and site proposers to refine the ROI definitions as we move forward.



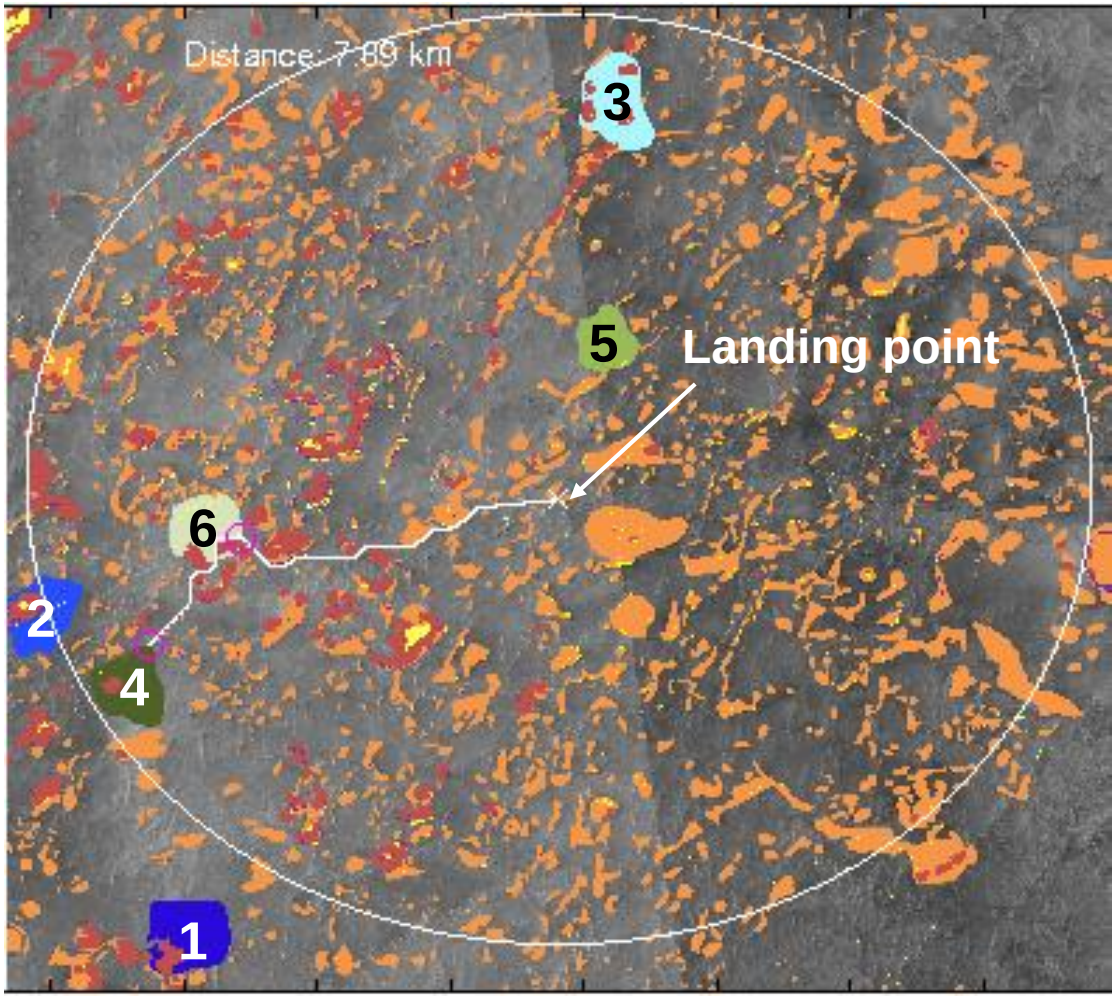
NE Syrtis
Any one of the ROIs 1 through 6
&
Any one of 1, 2, 4, or 6 that you didn't visit above



McLaughlin Crater
Any point on the contact between ROI #1 and #2
&
ROI #3

Optimal Route Planning

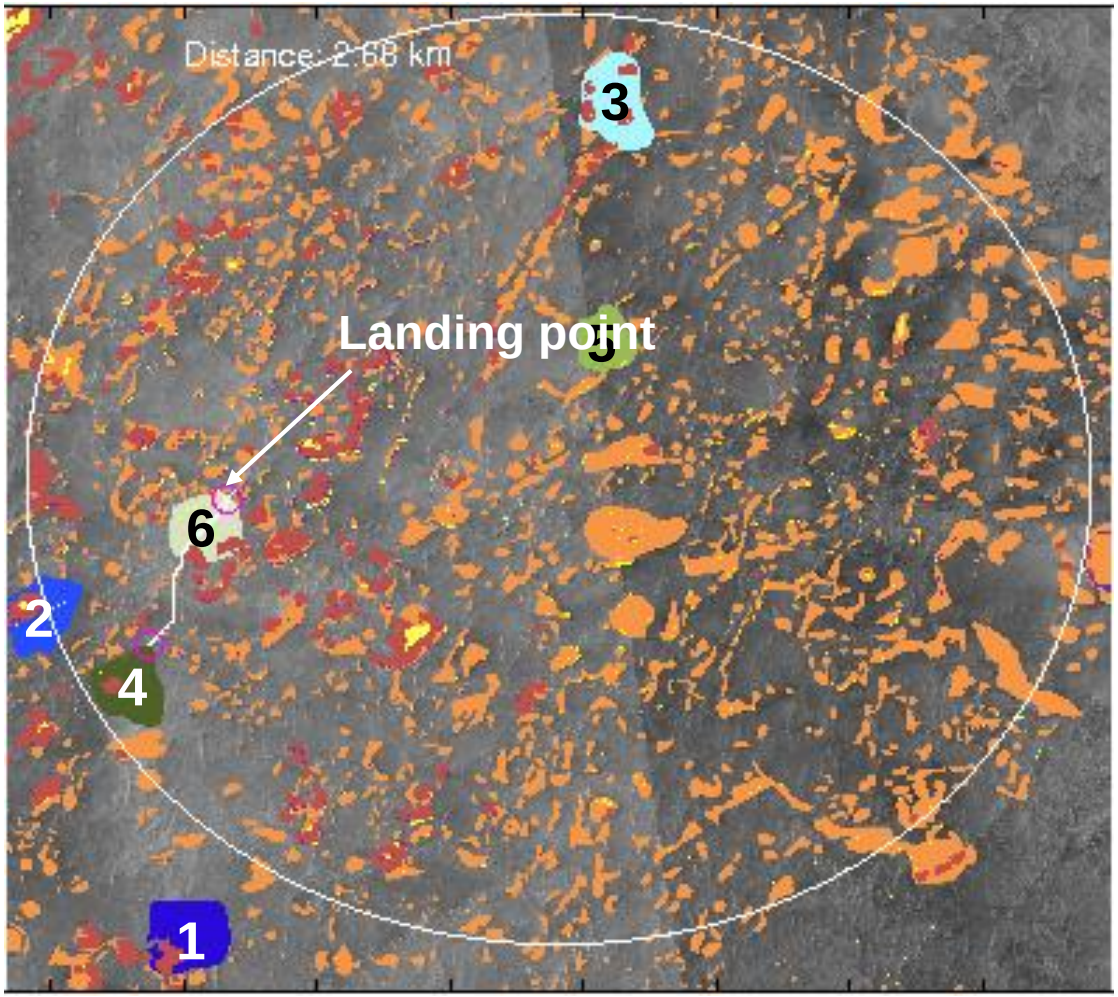
Example: NE Syrtis



- Minimize distance to achieve the minimum ROI requirement from a given landing point
- Optimal route computed by the newly developed Sequential Dijkstra algorithm

Optimal Route Planning

Example: NE Syrtis



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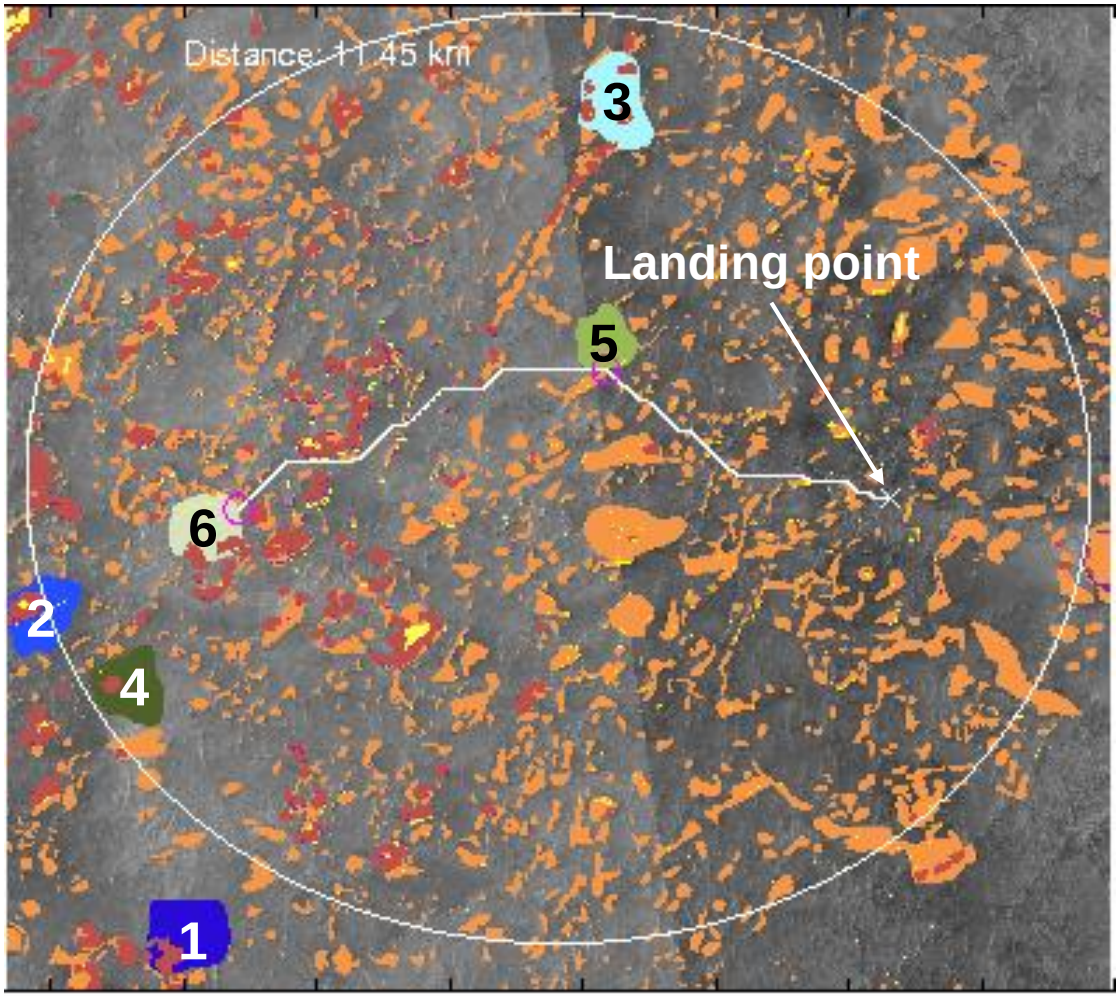
Optimal Route Planning

Example: NE Syrtis



- Minimize distance to achieve the minimum ROI requirement from a given landing point
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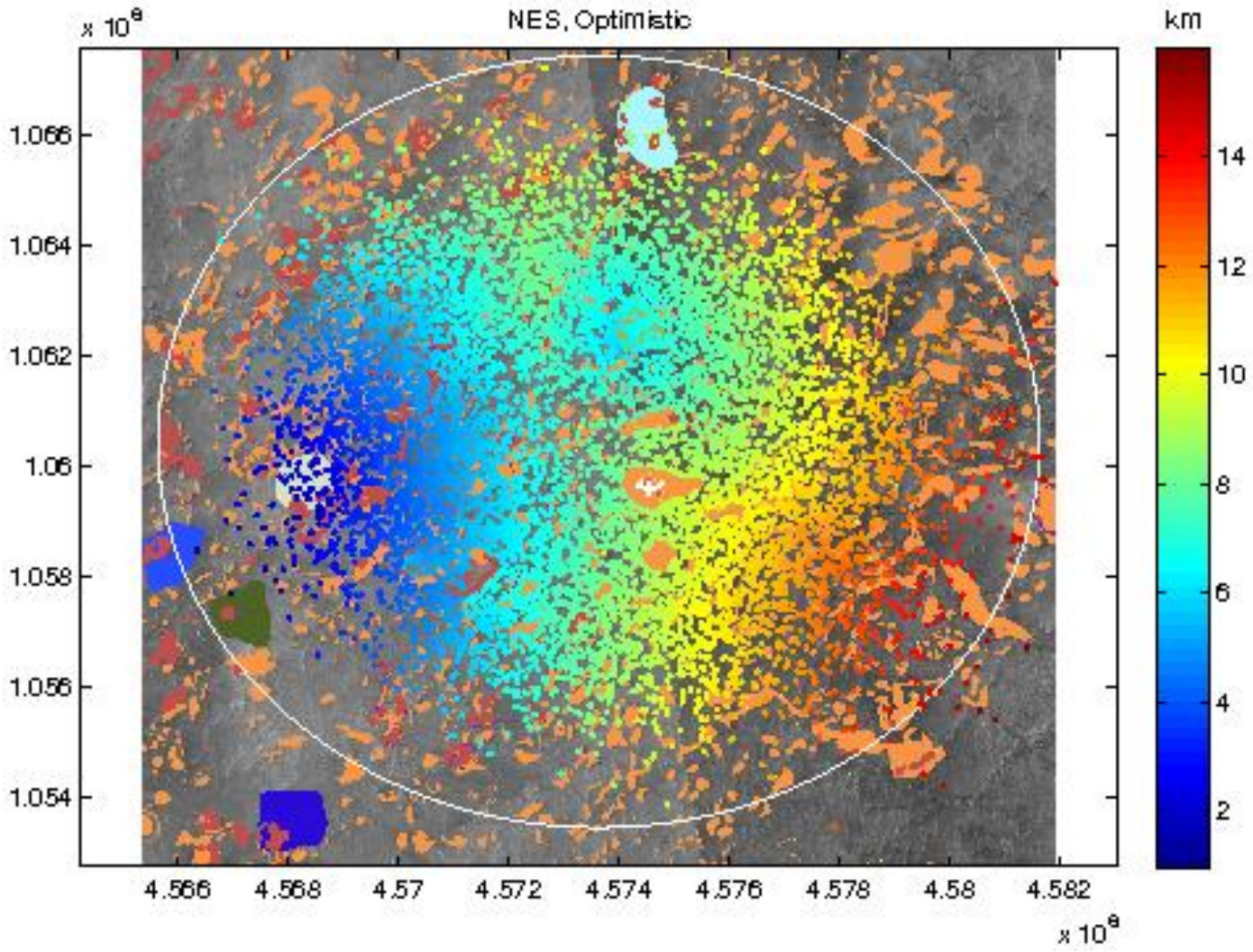
Monte-Carlo Simulation

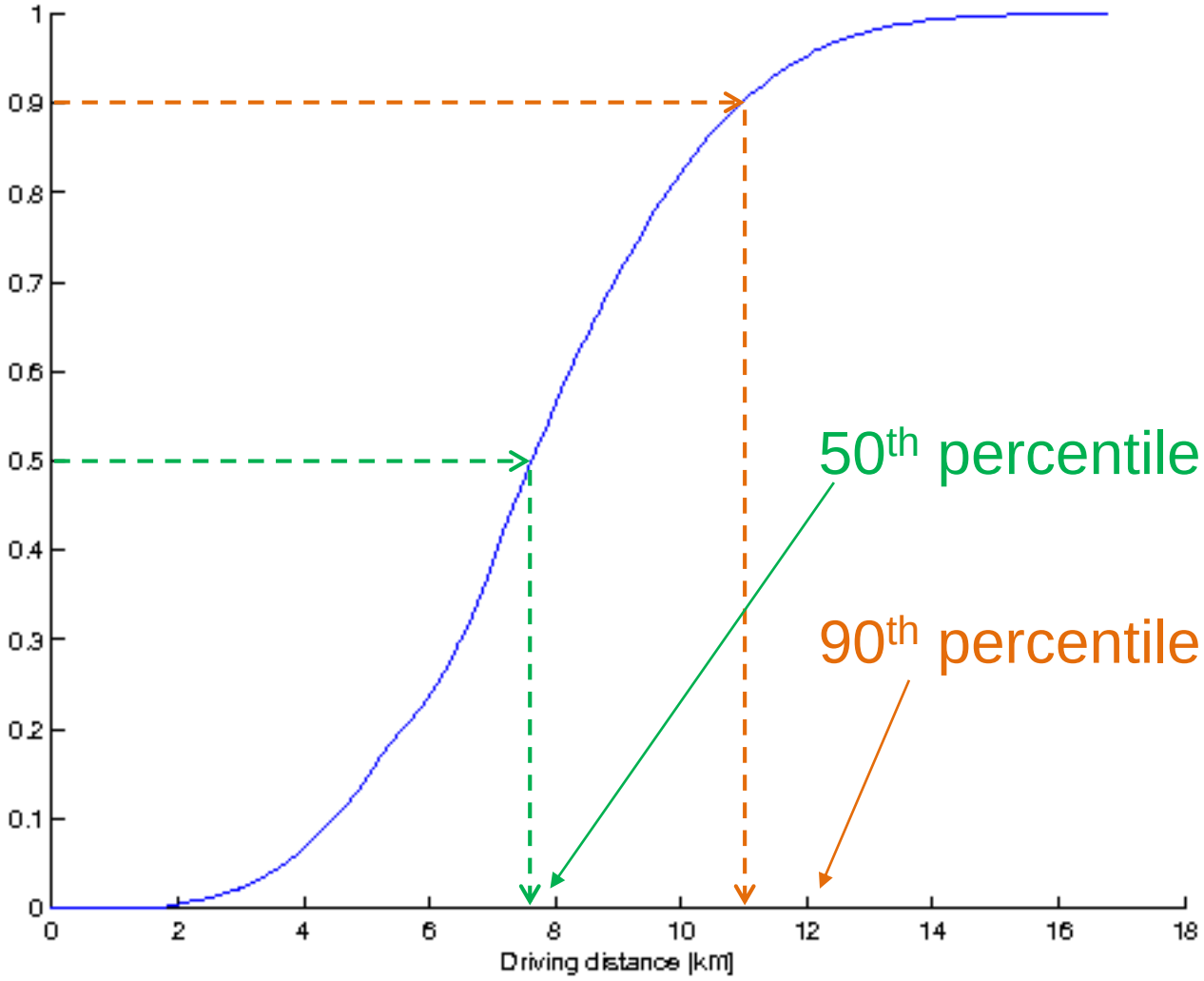


Landing points provided by EDL team

Consists of 8,000 samples

Optimal route computed from *all* samples

Cumulative Distribution of Distance



50th percentile distance: 7.8 km

90th percentile distance: 11.2 km

Inputs to Analysis

Traversability Hazards

Slope

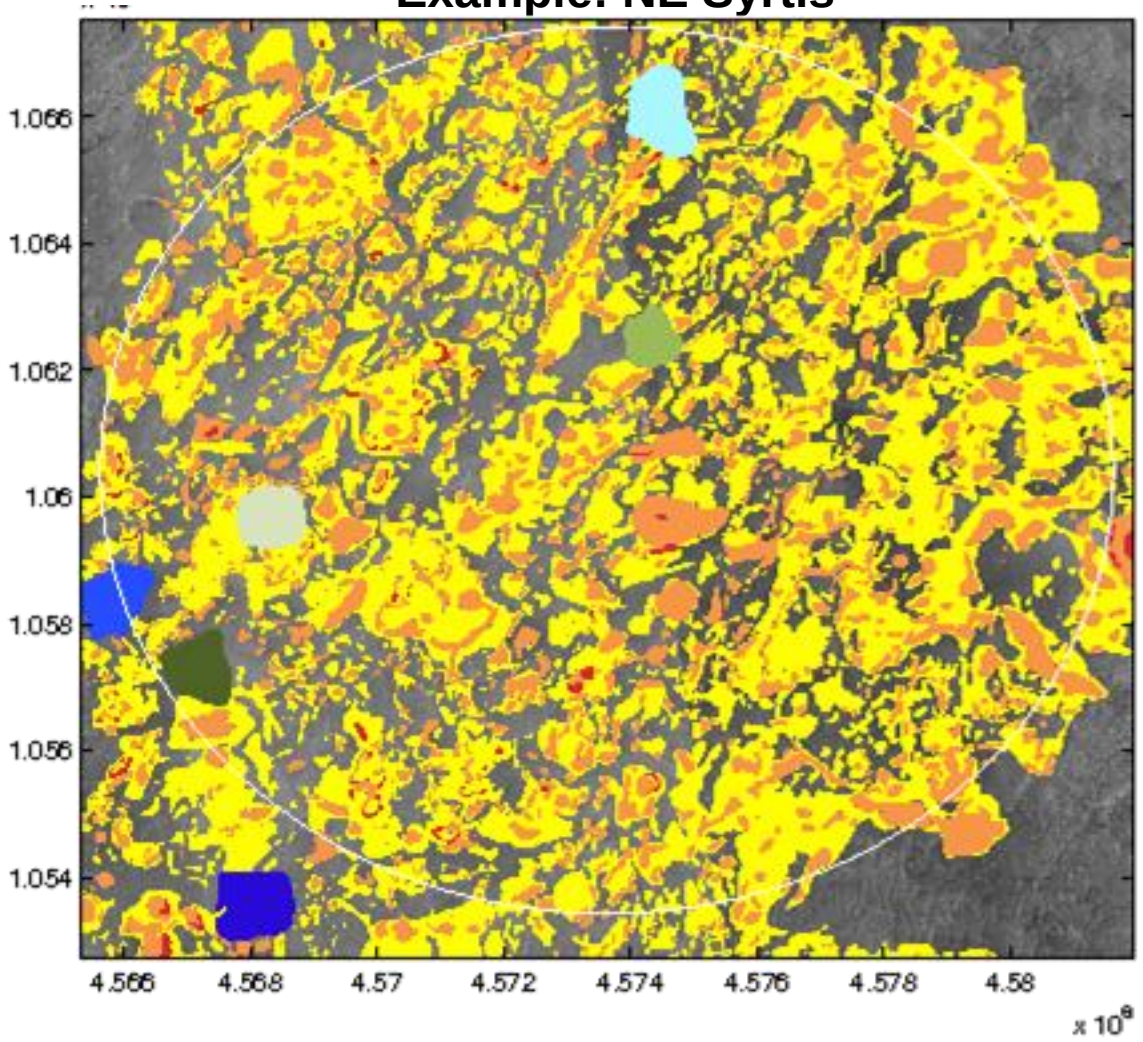
Rock Abundance

Data Availability

	Hazard	Slope	Rock
NE Syrtis			
Jezero			
Nili Fossae Trough			
Holden			
McLaughlin			
SW Melas			
Mawrth			
E Margaritifer			

Hazard Map

Example: NE Syrtis



- Manual assessment by Heverly
- Use HiRISE mosaic with 1m resolution
- Assume that red and orange are untraversable

Benign Terrain

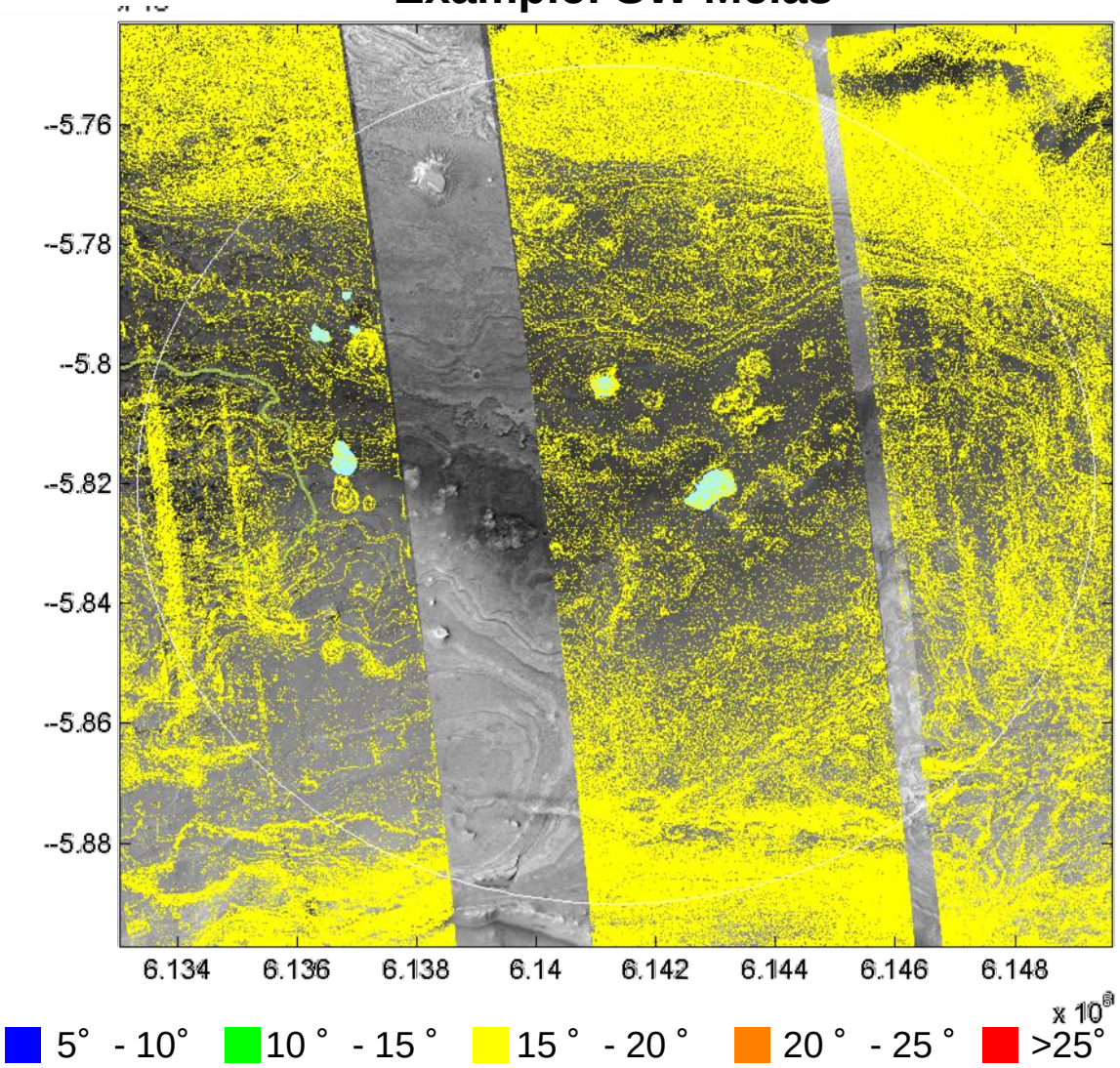
Complex Terrain

Would not choose to traverse

Non-Traversable

Slope Map

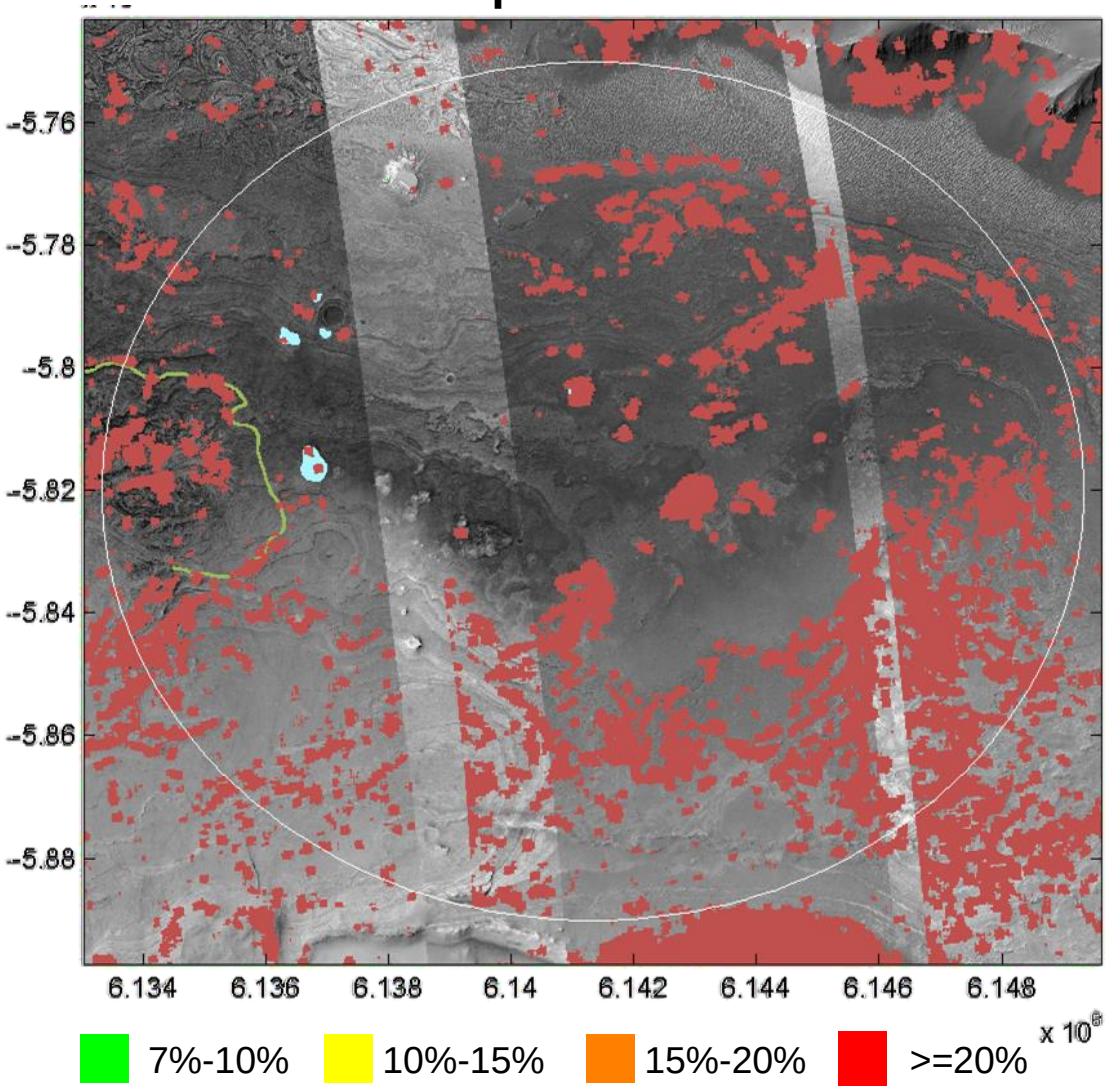
Example: SW Melas



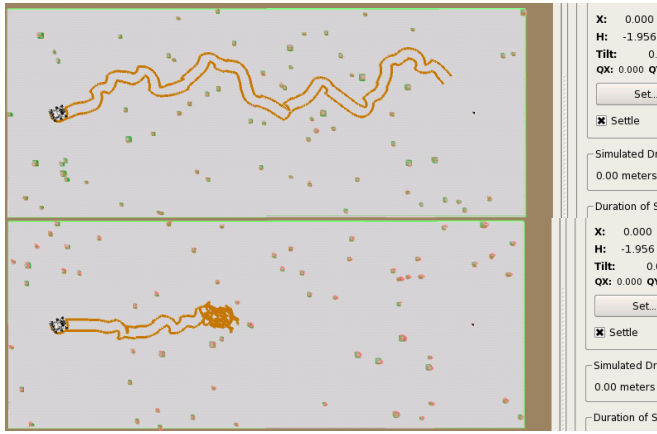
- Generated from HiRISE DEMs
- 1m resolution
- Typically does *not* cover the entire ellipse
- Threshold: 12° based on MSL's experience on soft soil

Rock Abundance (CFA) Map

Example: SW Melas

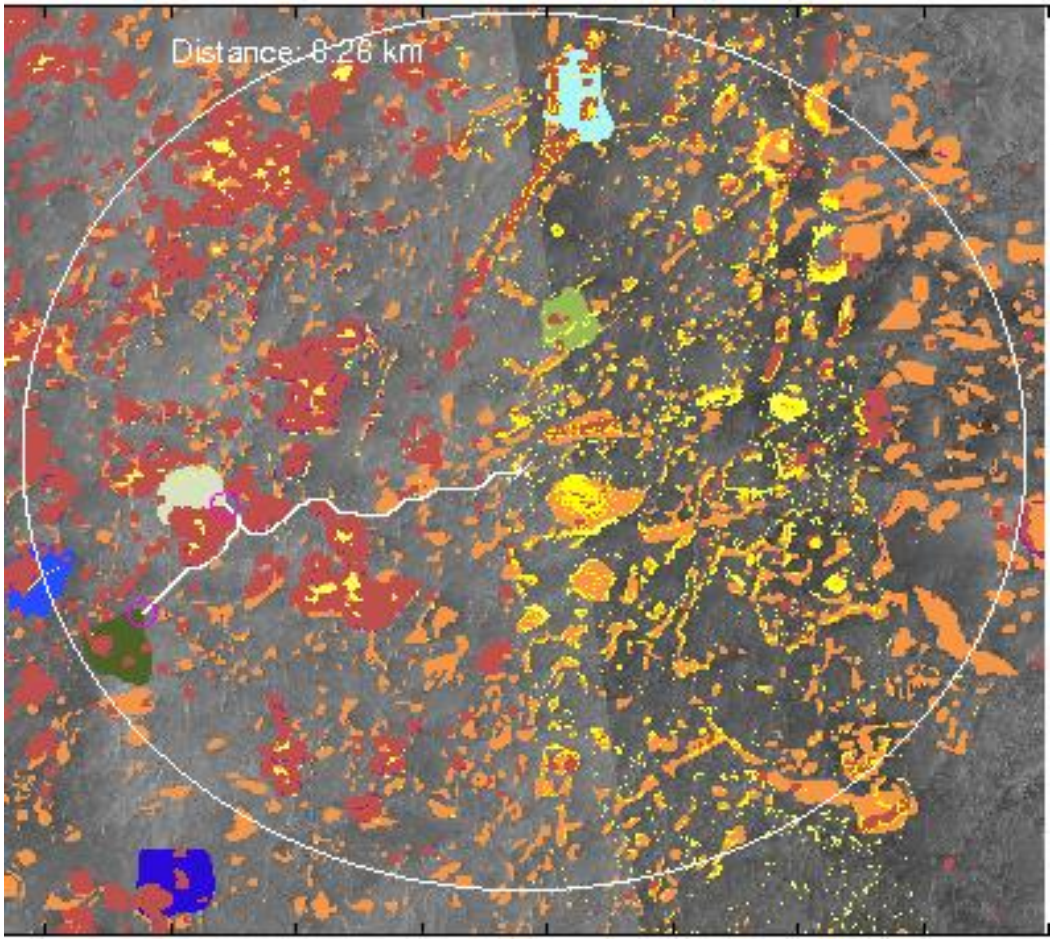


- CFA = **c**umulative **f**raction of **a**rea covered by rocks
- Based on rock counts on HiRISE images
- Automated rock detection algorithm by A. Huertas
- 15% threshold based on simulation



Combined Traversability Assessment

Example: NE Syrtis



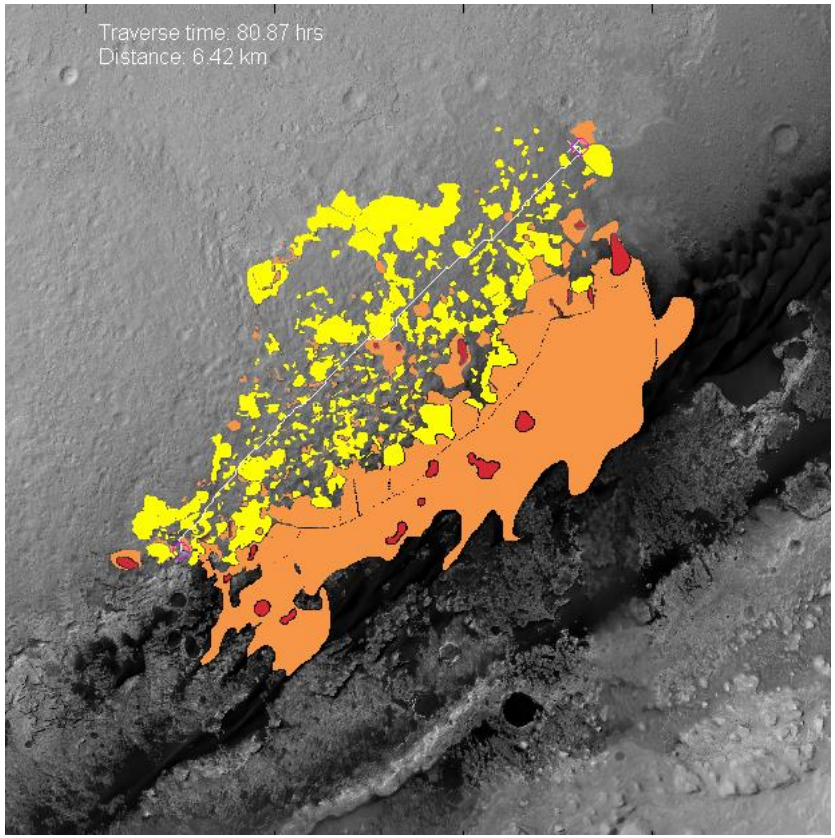
- Use *all* available data for each site
- Assume conservative thresholds on slope and rock abundance
  - 12 deg for slope
  - 15% for CFA

Gale Crater Example

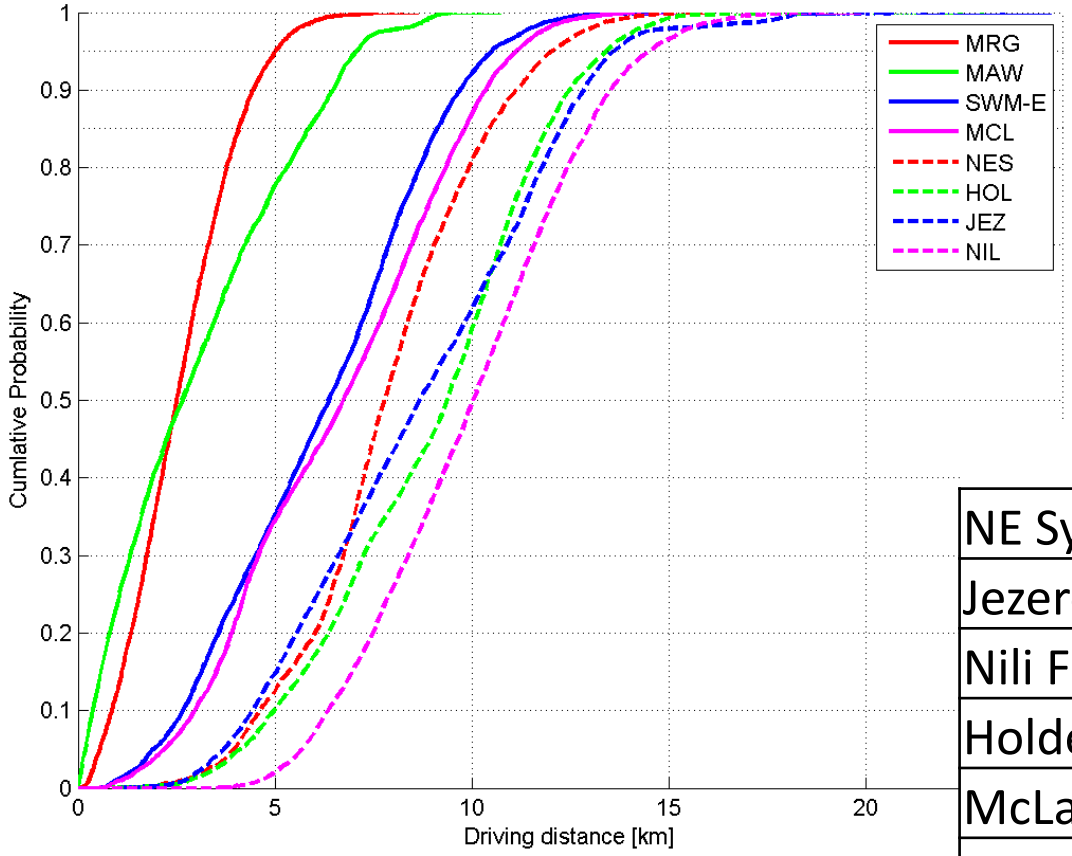
- To get an estimate of fidelity traverse distance estimation was done in the same way for Gale Crater
- Route planner shows 30% less distance than actual vehicle odometry between Yellowknife Bay and Pahrump

Actual traverse from Yellowknife Bay on sol 324 to arrival at Pahrump Hills on sol 753 has vehicle odometry of 8.6km

Route planner from orbital data gives 6.4 km (under estimate of ~30%)



Results



- Clear difference between "go to" and "land on" sites
- Placement and number of required ROIs has a big impact on traverse distance

	50%	90%
NE Syrtis	10.1 km	14.6 km
Jezero Crator	11.3 km	16.8 km
Nili Fossae	13.1 km	17.6 km
Holden (Land-On)	12.2 km	16.4 km
McLaughlin Crater	8.7 km	13.5 km
SW Melas	8.3 km	12.6 km
Mawrth Vallis	3.5 km	8.5 km
E Margaritifer	3.3 km	5.7 km

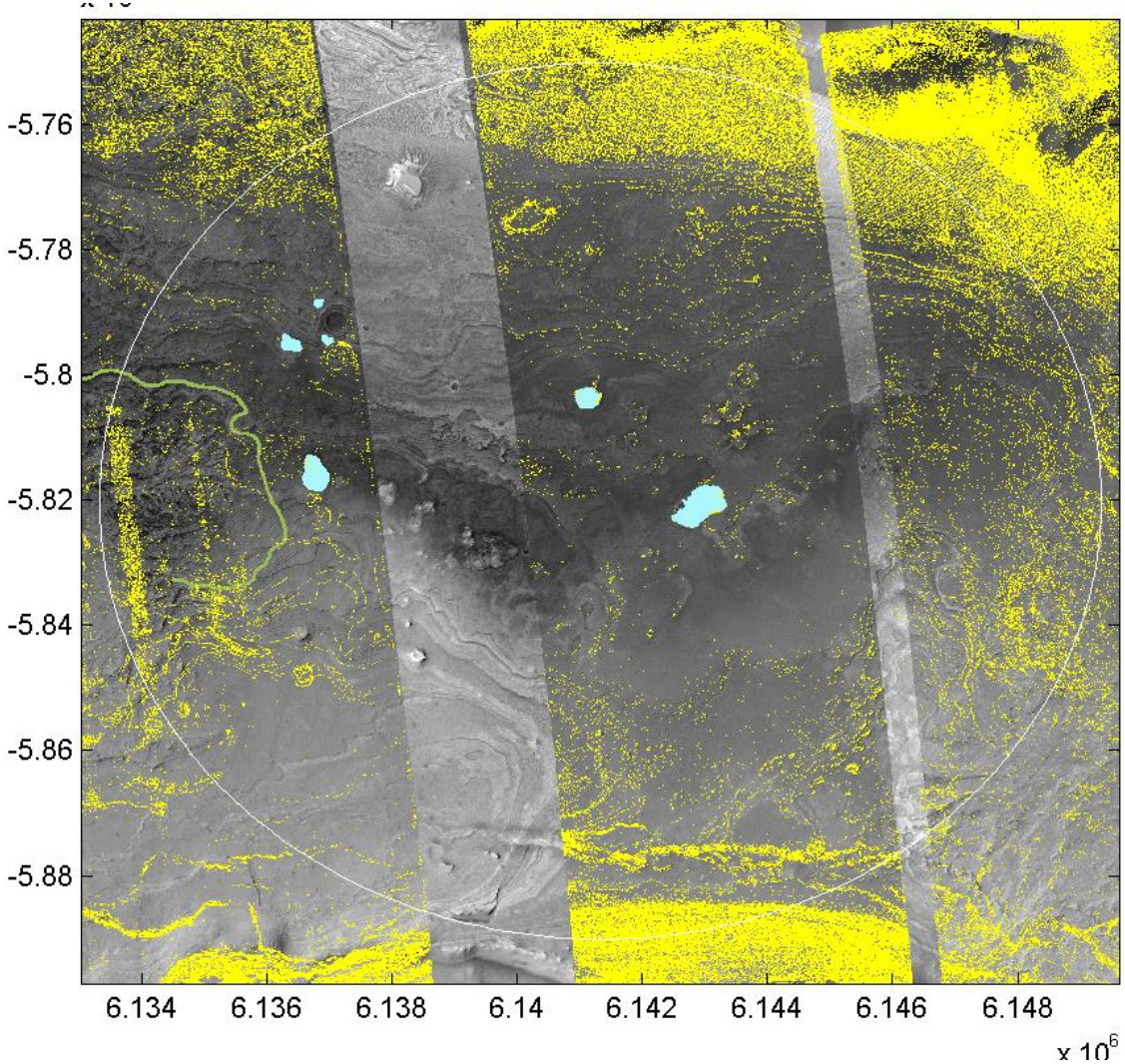
Values represent potential vehicle odometry and include 30% increase over map distance

- Work to go to mature these initial estimates
  - More traversability data for each of the sites
  - Refined ROI definitions

Backups

Slope: Binary Traversability

Example: SW Melas

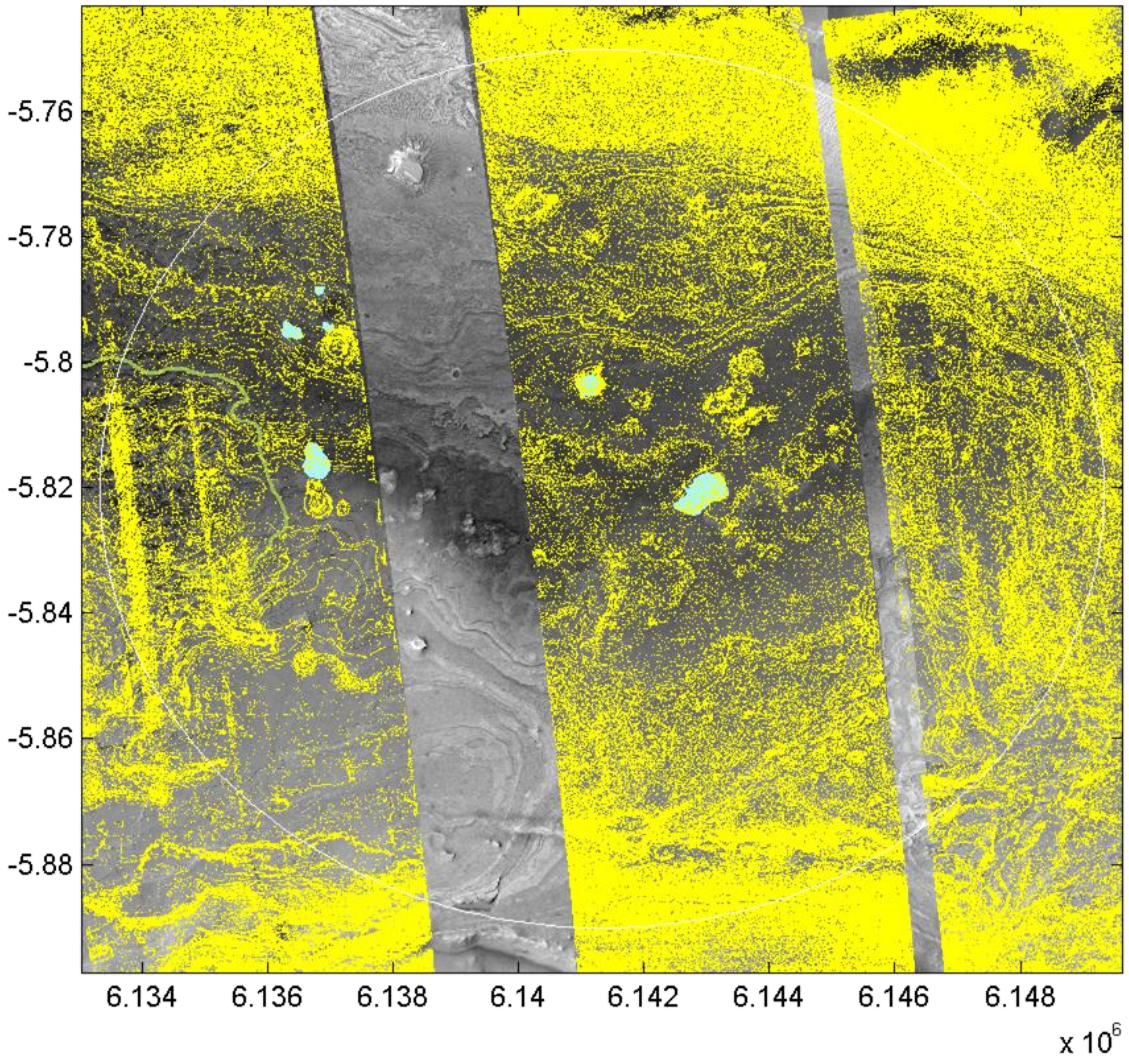


Threshold: 25°

Assumption:
Slope above threshold is untraversable

Slope: Binary Travsersability

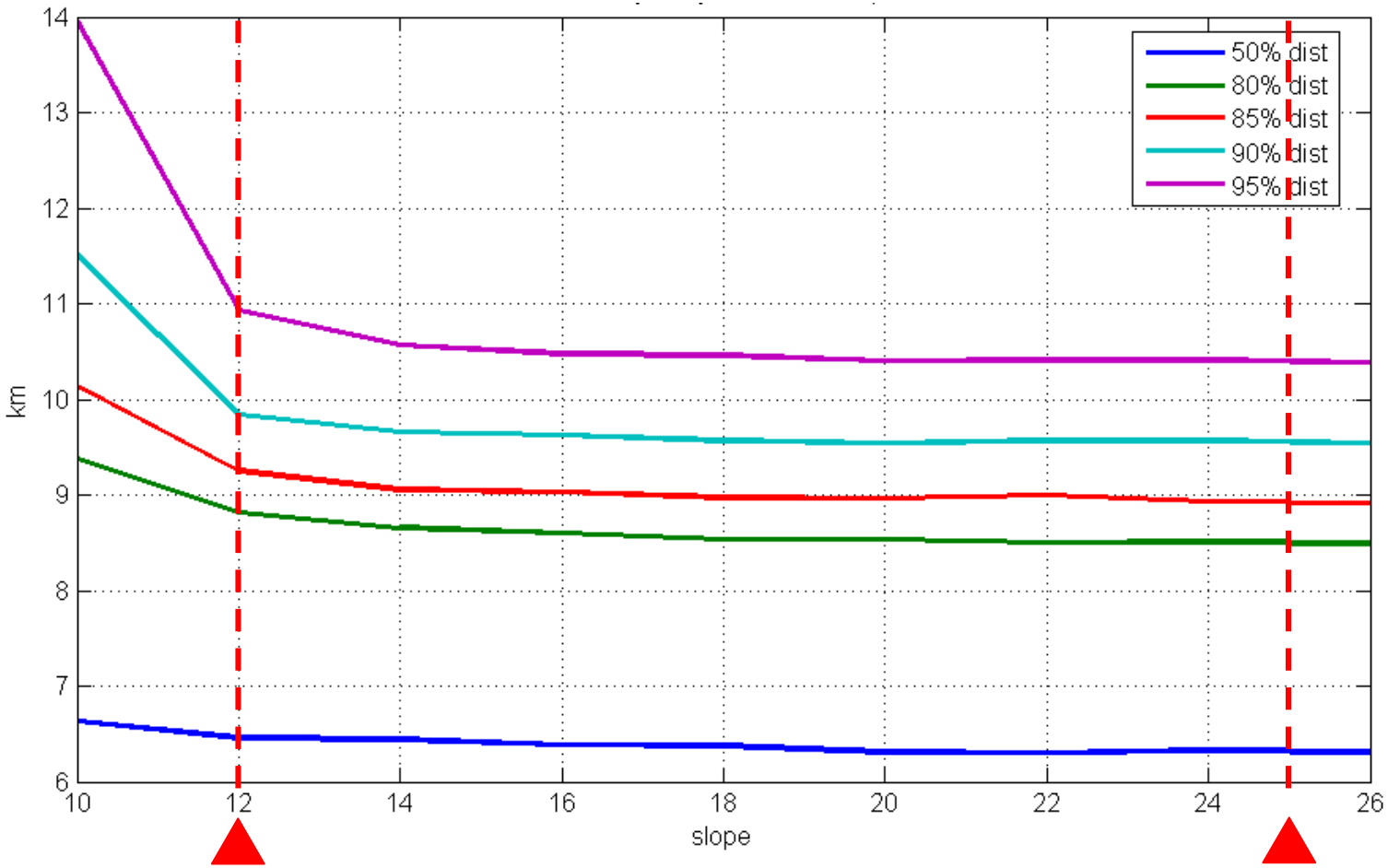
Example: SW Melas



Threshold: 12°

Assumption:
Slope above threshold is untraversable

Slope: Sensitivity



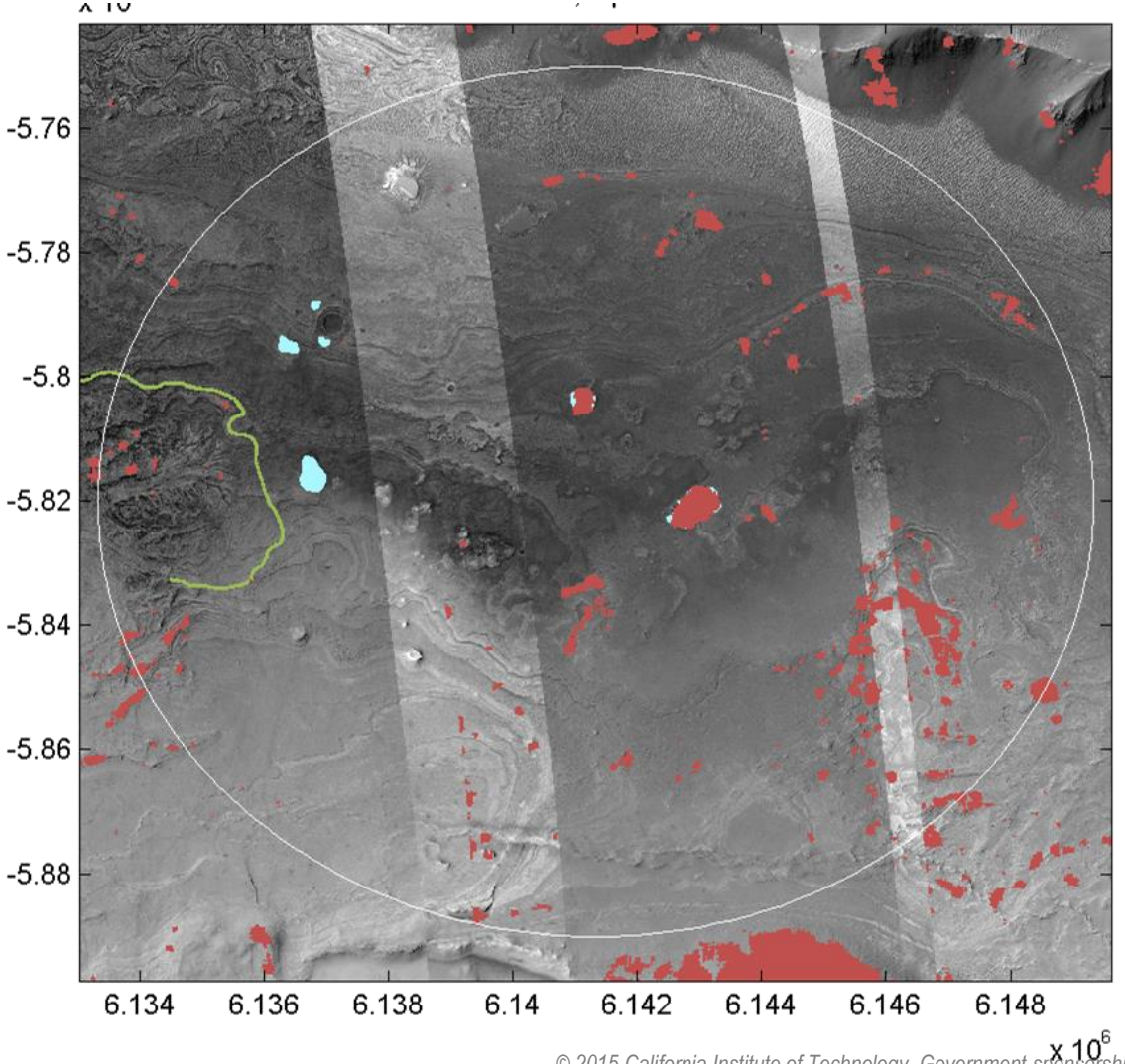
Conservative Assessment

Optimistic Assessment

Sensitivity analysis by E. Almeida

CFA: Binary Travsersability

Example: SW Melas

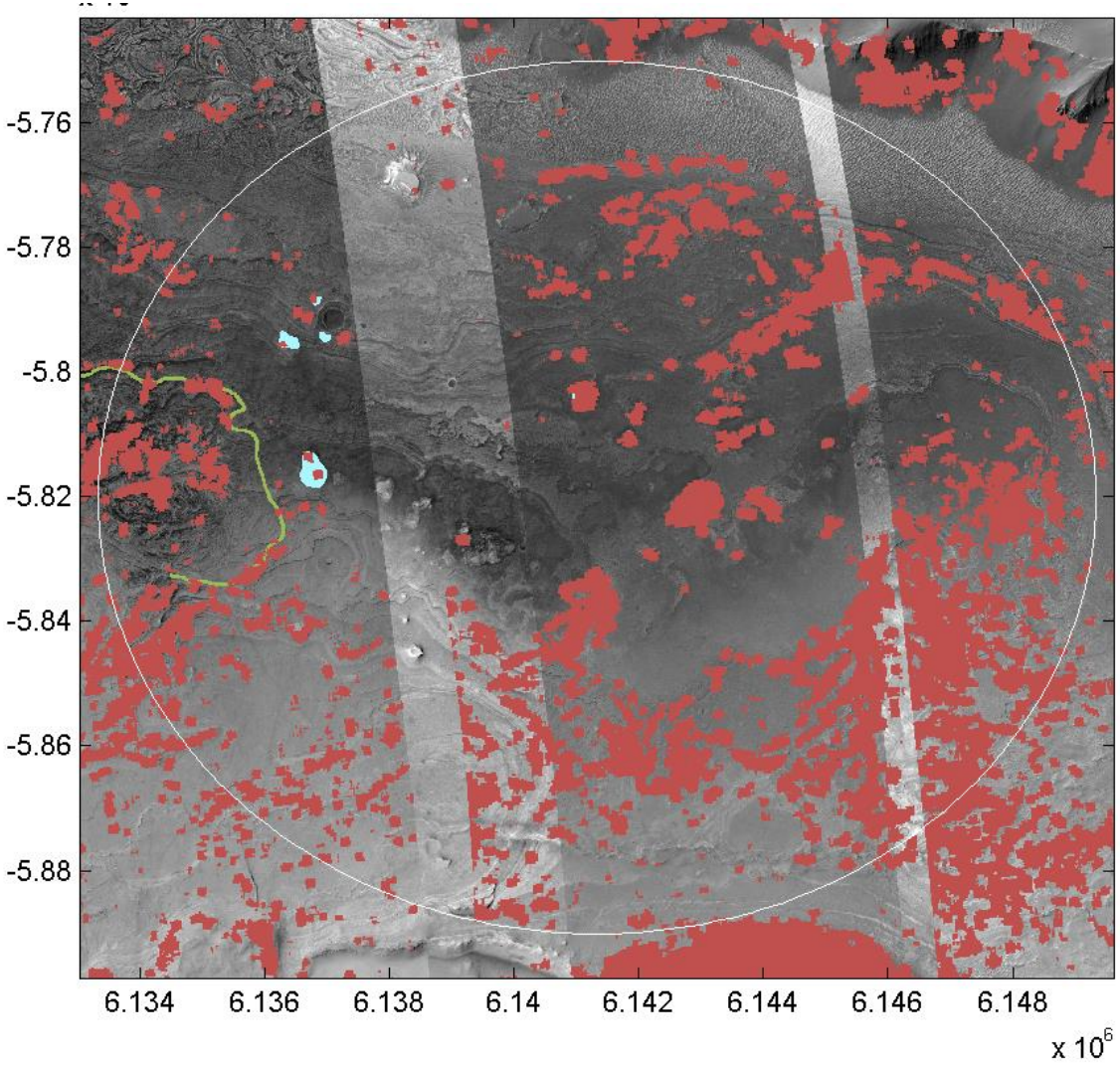


Threshold: 15%

Assumption:
CFA above threshold is untraversable

CFA: Binary Travsersability

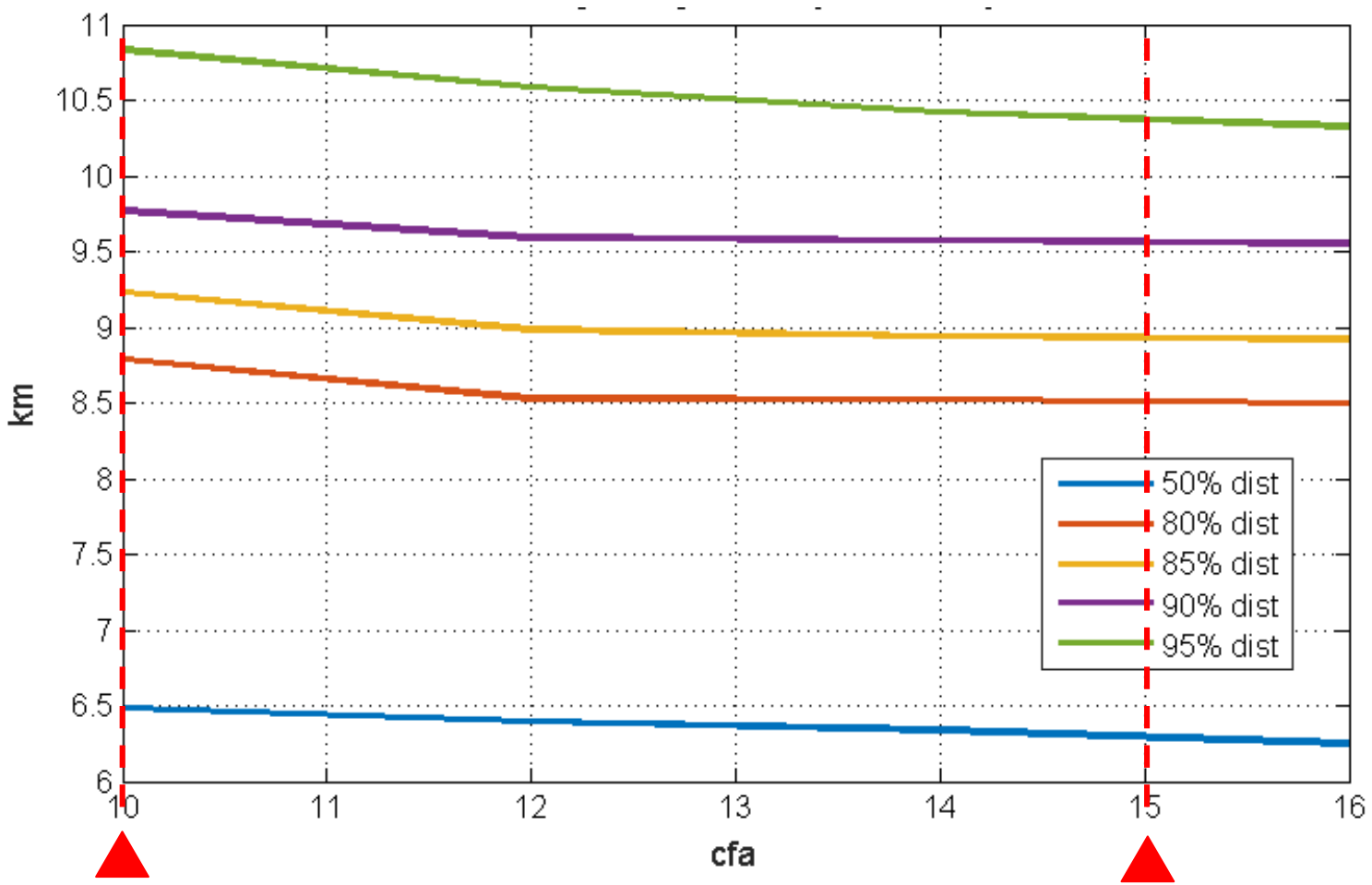
Example: SW Melas



Threshold: 10%

Assumption:
CFA above threshold is untraversable

Rock Abundance: Sensitivity



Conservative Assessment

Optimistic Assessment

Sensitivity analysis by E. Almeida

Assessment Types

Three assessments are performed for each site

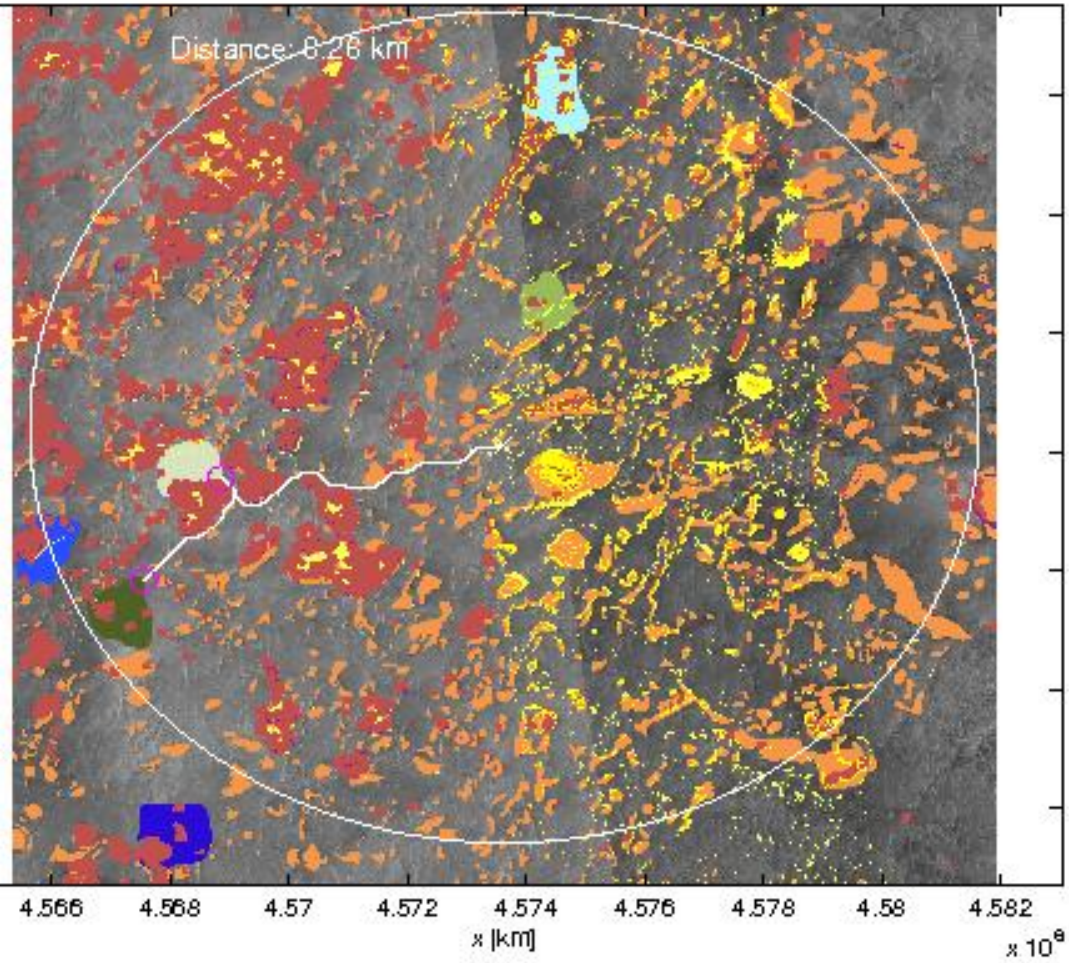
Conservative Assessment

Optimistic Assessment

No-Hazard Assessment

Conservative Assessment

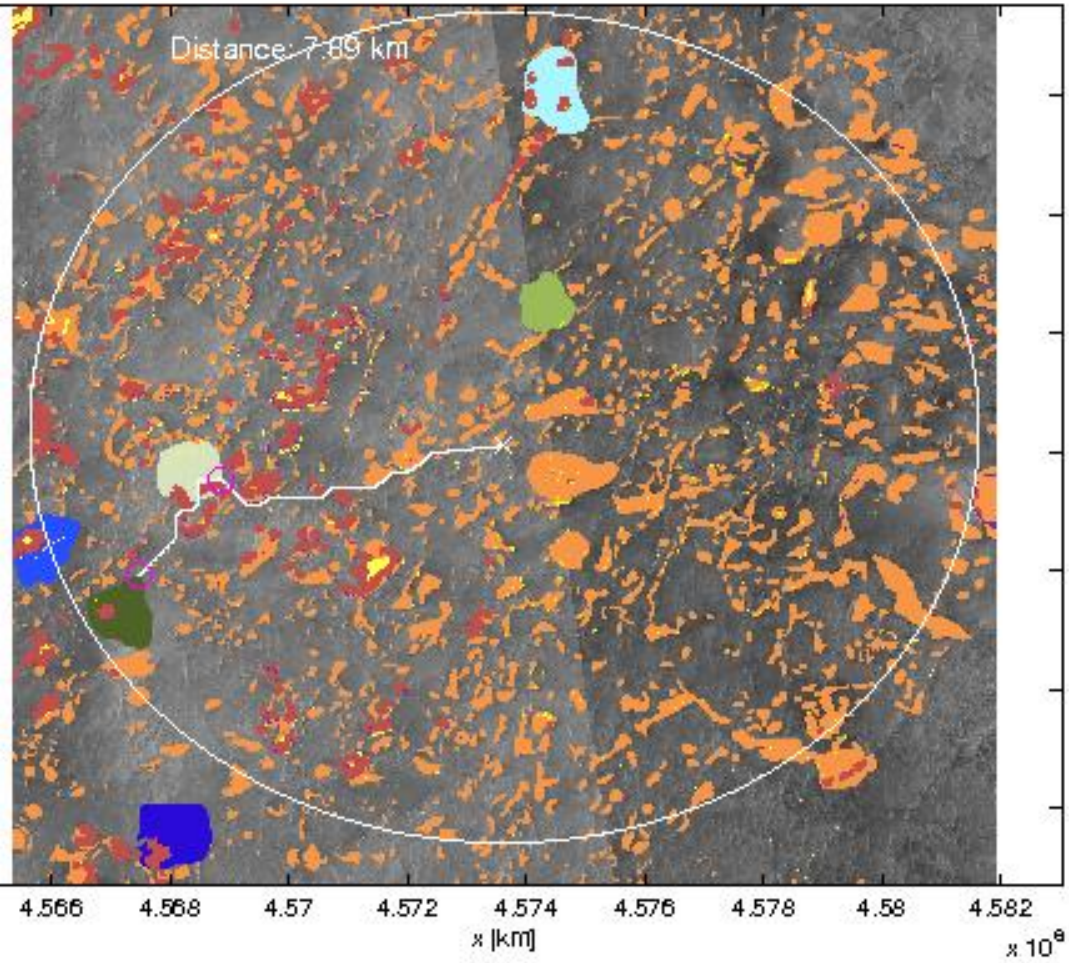
Example: NE Syrtis



- Use *all* available data
- Assume conservative thresholds on slope and rock abundance

Optimistic Assessment

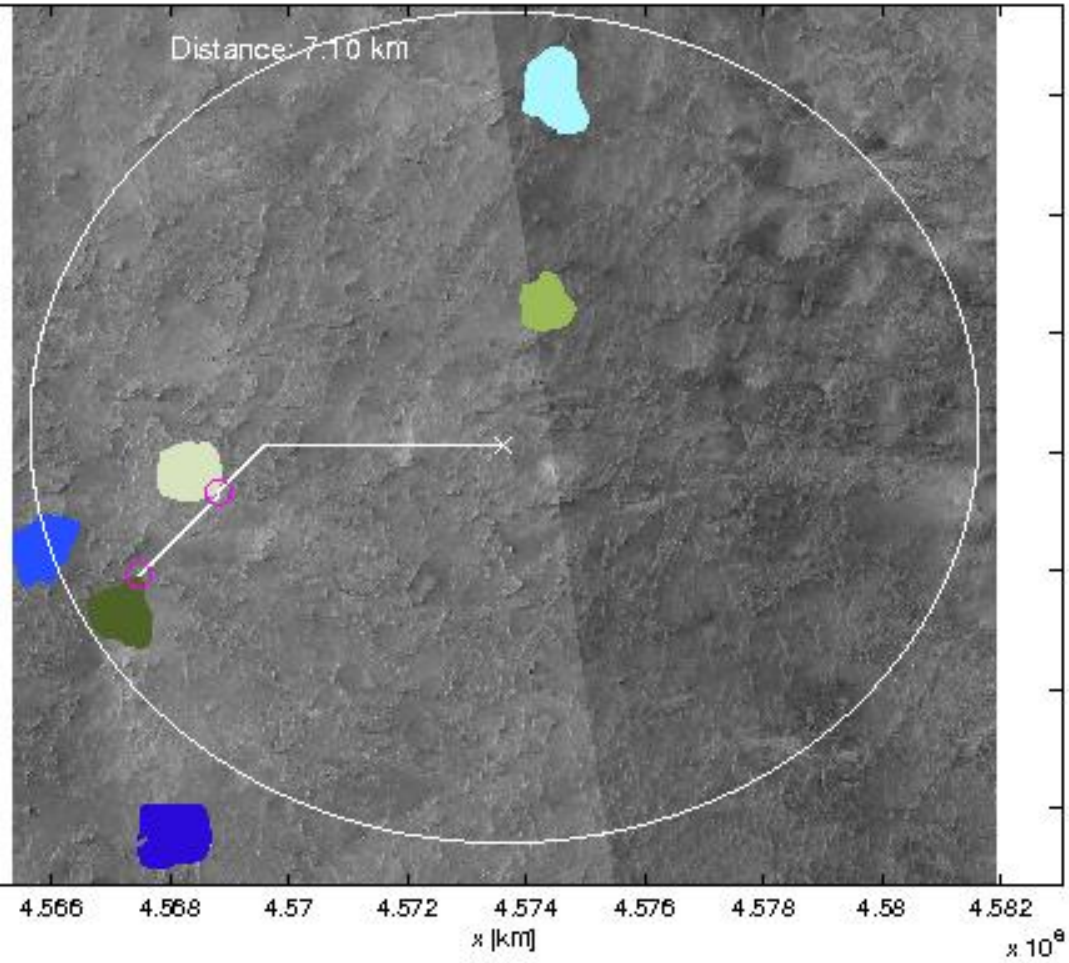
Example: NE Syrtis



- Use *all* available data
- Assume optimistic thresholds on slope and rock abundance

No-Hazard Assessment

Example: NE Syrtis



- Assuming that the entire site is traversable
- Gives lower bound on distance to achieve scientific success
- Allows to compare sites on the same basis